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[Reprinted from the Proceedings of the Boston Society of Natural History,
Vol. XIX, pp. 338-364, 1878.]

SKETCH OF THE LIFE AND SCIENTIFIC WORK OF PROFESSOR CHARLES FREDERIC HARTT, BY RICHARD RATHBUN.

In the death of Professor Charles Frederic Hartt, chief of the Geological Commission of the Empire of Brazil, we recognize one of the saddest losses science has recently suffered.

Prof. Hartt was just in the prime of life, full of vigor, with a mind already richly stored with the results of more than twenty years of almost constant exploration and investigation. Had he been advanced in years, with his labors nearly completed, although he might have become more endeared to us through longer association and friendship, yet we could then have consoled ourselves with the thought that he had finished the work he laid out for himself. But such was not the case; he left the great work of his life only just begun. His time was wholly given to the solution of some of the most intricate problems in the fields of science and the arts, but only here and there, in his short publications, do we catch glimpses of the inexhaustible store of facts he had accumulated and theories he had devised.

He was at one time an active member of this Society, and a student at the Museum of Comparative Zoology in Cambridge, and nowhere did he have a larger circle of sympathetic friends, than among his scientific associates at these two institutions, some of whom were students with him under Prof. Agassiz. To these, and to his co-workers everywhere, it would be needless for me to eulogize his character. He was hard-working, unselfish, and affectionate, never overbearing to his inferiors, but ever

showing the same respect for those laboring under him as for his equals. His deep sense of right caused him to weigh the claims of others generally more fairly than his own, and to his own loss. He was gifted to a wonderful degree with an original and inventive mind; while his early training laid a firm foundation for a life of great usefulness. Thus richly endowed he had started upon a most enviable career, and gave promise of attaining the highest eminence. His tastes were varied, leading him into natural science, language, art, and music, in all of which he accomplished original work of the highest grade. He loved study, and always entered with his whole soul into the investigation of whatever subject interested him. He was filled with a noble ambition and actuated by the purest purposes, and thus ever sought to advance the interests of science without thought of personal gain. In his short life he accomplished much, but so great was his confidence in the future, that he withheld the publication of many of his discoveries until they should be further developed and perfected, little expecting so sudden a termination of his work.

Although linguistic studies, as well as art and music, were to him favorite subjects of investigation, they were generally treated from a scientific stand-point, and were made subordinate to the more special field of inquiry, geology, to which he early became enthusiastically devoted. With an ever increasing love for scientific research, which finally came to absorb his whole attention, he died a martyr to science. Eminently successful as a teacher, his students shared his deep enthusiasm, and his influence upon science will long be felt through the labors of those who enjoyed the advantages of his careful training.

Prof. Hartt was the oldest son of the late Jarvis William and Prudence (Brown) Hartt, and was born at Fredericton, New Brunswick, August 23, 1840; he died at Rio de Janeiro, March 18, 1878. His last illness was of scarcely more than forty-eight hours duration; his death was sudden, and until the end, entirely unlooked for even by

those who were watching over him. He was attacked with a light fever on a Friday night, and this continued without dangerous symptoms until nearly midnight Sunday, when he became delirious. In this state he remained until three in the morning, when he passed away. The unexpectedly fatal termination of his illness can be accounted for, only on the supposition that his system had become greatly enfeebled by his constant, hard work and anxiety during the long, tropical summer. He had been accustomed to leave Rio in the hot season, but this year circumstances prevented his doing so.

Hartt's early education was carried on under the direct supervision of his father, who, for a long time, was prominently identified with the educational interests of Nova Scotia and New Brunswick. He studied at Horton Academy in Wolfville, N. S., and afterwards at Acadia College, where his father was at the time a professor. In 1860 he graduated from the College with high honors, receiving the degree of Bachelor of Arts, and later that of Master of Arts. In 1869 he was married to Miss Lucy Lynde, of Buffalo, N. Y., by whom he had two children, a son and a daughter. They all survive him.

At the age of ten, Hartt began to show a decided taste for natural history studies, in which he was aided and encouraged by his teacher, Prof. Cheeseman. His talent for drawing and for the acquisition of language showed itself at an equally early period, and we are told that he became an instructor of drawing at Acadia College when a mere boy. His liking for natural history was, however, the stronger, and he entered with great zeal into the work of geological investigation. Before he left college he had explored a large portion of Nova Scotia, which province he traversed from one end to the other on foot. In all his expeditions he made large collections of specimens, whenever there was opportunity. His studies always took the character of independent, original investigations, and their great value has served to identify him prominently with the history of Acadian geology.

In 1860 he removed with his father to St. John, N. B., for the purpose of organizing with him a college high school; but much of young Hartt's time was at once devoted to the exploration of the rocks in the vicinity of St. John. It was these researches that first made him widely known to the scientific world. His discovery of the remains of fossil insects in the Devonian shales of St. John attracted the attention of Prof. Agassiz, and helped to decide the future course of the young provincial geologist. Accepting an invitation from Prof. Agassiz to become a student at the Museum of Comparative Zoology, he went, in 1861, to Cambridge, where he spent the greater part of the next four years. Here he diligently improved the great opportunities afforded for study and original research, and made rapid progress. The great temptation to devote himself to the investigation of the immense stores of undescribed material contained in the Museum, did not entirely withdraw his attention from the study of the geology of his native land, his vacations being mostly spent in continuing the explorations already begun in the Provinces.

Before he went to St. John in 1860, the geology of southern New Brunswick was very imperfectly known, and it was about this time that careful researches were begun. Hartt carried on his work, partly alone, and partly in connection with the Survey of southern New Brunswick, under Prof. L. W. Bailey. He did not, however, confine himself to New Brunswick, but gave much time to the study of the geology of Nova Scotia. His name figures prominently in the report of Prof. Bailey, published in 1865, and also in Dr. Dawson's "Acadian Geology," (2d ed., 1868). Many of his results were published in the reports of others, and it is thus difficult to tell how much we should accredit to Hartt; but some of his results have been given us separately, so that we are able to make the following general summary of his principal discoveries in the Provinces.

In 1861 he discovered that the Devonian shales at Duck Cove, Lancaster, near St. John, were richly fossil-

iferous, and contained, in addition to the many remains of land plants, fossil insects, the oldest of any known to science. Mr. Geo. F. Matthew, of St. John, had previously found a few obscure plant fragments in these same beds, and also in the shales at the foot of the city of St. John. These were described by Dr. Dawson, who also worked up most of the species afterwards obtained by Hartt. Mr. Hartt's observations on these beds were continued through the years 1861, '62, and '63, and he has given us, as a result of his labors, a minute description of the several beds and their fossil contents. Of insects there were discovered five species, represented by fragments of wings only. Mr. S. H. Scudder, who studied them, has referred them all to the Neuroptera, in part to new, in part doubtfully to old, families, and suggests that some of the forms represent synthetic types.

Mr. Hartt, in connection with Prof. Bailey and Mr. Matthew, made in 1864, the first large collection of fossils obtained from the Acadian or Primordial group in the vicinity of St. John. The principal localities examined were Ratcliffe's ravine and Coldbrook, at which latter place Mr. Matthew had previously discovered a few obscure forms. From these, however, no satisfactory conclusions as to the exact age of the beds had been attained. The new collections, consisting mainly of finely preserved trilobites, were placed in Hartt's hands for study, and by him worked up with great care at Cambridge, Mass. He published, in 1865, his preliminary report upon them, in which he proved that the beds in which they were found are equivalent to about the "étage C" of Barrande, or the Potsdam group proper of America. This report contained the first positive evidence of the existence of Primordial strata in New Brunswick. Descriptions of the principal fossils by Hartt, with many figures, are contained in Dr. Dawson's "Acadian Geology" (1868).

It was also in 1864 that Hartt obtained proof of the Pre-Carboniferous age of the gold of Nova Scotia. His

observations were made at a place called Corbitt's Mills, where the well known auriferous Silurian slates are immediately overlaid, unconformably, by conglomerates, grits and sandstones of Lower Carboniferous age. The lower portion of the conglomerates and grits also contain an abundance of gold, which was undoubtedly extracted from the underlying slates, while the former deposits were in process of formation, and was mixed with the loose gravel material which afterwards became consolidated.

We owe to Hartt the careful investigation of the relations of the different members of the Carboniferous limestone deposits, in the neighborhood of Windsor, Stewiacke, etc., Nova Scotia. He collected and studied the faunæ of each separate set of beds with much pains, and in this way was enabled to determine their sequence. The fossils, which are marine, are very numerous, and some new species were described by him in the "Acadian Geology." Much interest attaches to the study of this formation at the above localities, where, in the upper beds, occur many forms common to both the Carboniferous and the Permian, and a great likeness is apparent to the upper members of the Carboniferous system in the western United States, called Permo-Carboniferous. Dr. Meek, who examined the fossils, suggested that we might have here "what Barrande would call an upper Coal-measure, or even Permo-Carboniferous fauna, 'colonized' far back in the Sub-Carboniferous period." Dr. Dawson has greatly enlarged on Hartt's results, and shows that the divisions made by him are of a more general character than he had supposed.

In many places in his "Acadian Geology," Dr. Dawson refers to the work of Prof. Hartt in various parts of Nova Scotia and New Brunswick, and it is known that, at the time of his death, he had still remaining some original material from the Provinces which he never had the time to study or publish.

Upon the organization of the Thayer Expedition to Brazil, by Prof. Agassiz, Mr. Hartt was appointed one

of its two geologists, Mr. Orestes H. St. John being the other. This expedition left New York in April, 1865, and returned in July, 1866, having been absent a little more than a year. This was the strong and final inducement that called Hartt away from the geology of his own country. Although he was not fortunate in finding a very rich geological territory during his wanderings, while connected with the Thayer Expedition, he saw enough to thoroughly interest him in returning again to Brazil, and in finally giving his whole attention to Brazilian studies. There is little necessity for going minutely over the details of his first few trips to that country. Accounts of them have been published, and are easily accessible.

The primary object of the Thayer Expedition was the investigation of the distribution of the fresh-water fishes of Brazil, but much time was also devoted to the study of its geology. No new fossiliferous deposits or localities were discovered, and of those already known, only the Cretaceous at Bahia, and the Post-Pliocene of Lagoa Santa, were visited. Professor Agassiz limited himself mostly, in his geological work, to the examination of the superficial deposits at Rio de Janeiro and on the Amazonas, which were studied in connection with the question of glaciers. Hartt was retained near Rio for some time, in making examinations of the many cuttings around that city. After this work was completed, his field of exploration lay mostly between Rio and Bahia, where, with Mr. E. Copeland, of Boston, as a companion, he carefully studied the geological and other features of the coast, and of the principal river basins leading to it. Large collections of the fresh water fishes of the rivers, and of the marine animals of the coast and reefs, were made. The region from Rio to Bahia is entirely metamorphic, consisting mostly of gneisses, covered in large part with loose or only partially consolidated materials, without fossils. In consequence of this absence of fossils, no results in systematic geology were obtained, but, nevertheless, Hartt's studies of the geology of this

monotonous tract were of great interest. At the Colonia Leopoldina, in southern Bahia, he had the opportunity of observing the customs, etc., of the now nearly extinct Botocudo Indians.

In the neighborhood of Porto Seguro he explored the coral and sandstone reefs, which latter are such a prominent feature on the Brazilian coast. He was the first to carefully work out the structure and mode of formation of these sandstone reefs, although Darwin's short description of them is not far from correct.

After Hartt had returned to the United States from the Thayer Expedition, he felt that he had left unfinished some of the more important of the investigations he had made in Brazil. He was unable to report as fully as he wished on many subjects of interest which he had in part studied. So in 1867 he returned to Bahia, to better perfect his old work and continue his observations. He worked out the geology on the line of the Bahia railroad in detail, and collected some fossils from the Cretaceous formations which compose much of that region. He also studied the structure of the Abrolhos Islands and Reefs, which lie off the coast of Bahia, to the southeast of the town of Caravellas. The islands are of stratified deposits, capped with trap, while the reefs, which had never before been to any extent examined by a naturalist, are of coral generally assuming curious tower-like forms, and often growing together to form a large connected expanse.

In addition to throwing new light on the formation of certain kinds of coral reefs, he also discovered a large number of species of corals, of which the majority were new, but belonged to West Indian types. The entire absence from the Brazilian coast of many prominent West Indian genera, such as *Madrepora*, *Meandrina*, *Diploria*, etc., was noted by him. The Cretaceous region of Sergipe was visited, and yielded many fossils, which have been in part described by Prof. A. Hyatt.

In the short interval which elapsed between his first and second trips, he was engaged in scientific teaching and lecturing in, and near, New York city, at the Cooper

Institute, Pelham Priory, and other places, where he attained much success and made many warm friends who aided him in his second Brazilian expedition. In 1868, soon after returning the second time, he was appointed Professor of Natural History in Vassar College; but he resigned this position in the fall of the same year to accept the chair of Geology in Cornell University, where he was retained at the head of the department of geology until the time of his death. In 1869 he was elected General Secretary of the American Association for the Advancement of Science, to serve at the meeting of 1870, but before that time he had departed on his third trip to Brazil.

While at Cornell University, when not occupied by college duties, he was engaged in working up the results of his Brazilian explorations, and in preparing his report, as geologist to the Thayer Expedition. This report, however, grew to so large a size, and was so complete in itself, that it was found advisable to publish it separately, in 1870, as "The Geology and Physical Geography of Brazil." It forms a large octavo volume of over six hundred pages and contains, in addition to an account of his own researches, a résumé of our previous knowledge of the natural history of the country. It is thus not limited to a discussion of the subjects indicated by the title, but treats of the topographical and general features of the country, of its flora and fauna, both marine and terrestrial, and its mining, agricultural, commercial, and manufacturing interests. The numerous maps and sketches, with which it is illustrated, were drawn by Prof. Hartt himself. The greater part of them represent regions never before depicted. The subjects discussed, mostly from personal observations, are the following: The provinces of Rio de Janeiro and Espirito Santo; the Mucury and Jequitinhonha basins in Minas Geraes; the Abrolhos Islands and Reefs; the Southern coast of Bahia, and the vicinity of the city of Bahia and the Bahia Railroad; the provinces of Sergipe and Alagoas; the basin of the Rio São Francisco below the Falls; and the

vicinity of Pernambuco. His description of the interior of the province of Bahia, and the upper São Francisco basin, are made up largely from the notes of Messrs. St. John, Allen, and Ward of the Thayer Expedition. The volume closes with a valuable appendix on the Boto-cudo Indians.

From a review of his book, we find that the following geological formations were known, or supposed, to be present in Brazil at the time of its publication:—

Eozoic. The gneisses, etc., of the plateau of Brazil, including the Serra do Mar, and of the plateaus of Guyana and the Chiquitos region were, at least for the most part, referred to this age.

Silurian. It was suggested by Hartt that the clay and talcose schists, itacolumites, etc., of the gold regions of Minas Geraes are probably referable to the Silurian. They closely resemble similar formations in Nova Scotia. No Silurian fossils were found.

Devonian. Unknown.

Carboniferous. Including the beds of coal, with accompanying deposits, containing remains of plants, in Rio Grande do Sul. Prof. Agassiz, in "A Journey in Brazil," has referred to the finding of Palæozoic fossils by Major Coutinho on the Lower Tapajos, but it remained for Hartt to afterwards determine their Carboniferous age.

Triassic (?). A thick series of red sandstone, underlying the Cretaceous over a large part of Sergipe. No fossils were found.

Cretaceous. Existing through most of the northern coast provinces, and forming separated basins, partly of marine, partly of fresh-water, origin. Fossils had been collected at a few localities. The Cretaceous had also been found on the Rio Purus.

Tertiary. The clays and ferruginous sandstones of the coast, and of many of the river basins and plateaus, were referred to the Tertiary, although there were no palæontological evidences as to their age.

Drift. Prof. Agassiz's ideas of the distribution of drift were mostly accepted, and Hartt adds his own

personal observations made in the vicinity of Rio, Bahia, etc.

The above general account suffices to show how little was known of the systematic geology of Brazil, at the time when Hartt had finished his second trip to that country.

In the year 1870, the same in which his book was issued, Prof. Hartt organized the largest of his own expeditions from the United States. It was composed, besides himself, of Prof. Prentice and eleven students of Cornell University. His object in taking so many young men into a new field was to give them thorough practical training, and to stimulate them to undertake original work. He says, in his report of this expedition, that he did not expect to make scientists of them all, but hoped that some might be thus induced to accept that calling. Of that band of students he refers to four (O. A. Derby, T. B. Comstock, H. H. Smith, and W. S. Barnard), who are to-day doing scientific work of a high character. The means for defraying the expenses of the trip were contributed by several parties, most prominent of whom was Mr. E. B. Morgan of Aurora, N. Y., whose name has been given to this and the subsequent expedition.

Not having been successful in his former trips along the coast, in finding other fossiliferous deposits than the Cretaceous, Prof. Hartt determined to change his field of research, and explore the Amazonas. Accordingly, he went with his party directly to Pará, and in the neighborhood of that city spent some time in training his inexperienced assistants. The tributary rivers, Tocantins, Xingú, and Tapajos, were then examined throughout their lower courses, and many valuable geological facts ascertained. On the Tapajos were discovered the highly fossiliferous Carboniferous deposits from which, as already mentioned, Major Coutinho had before obtained some undetermined fossils.

At the falls, on each of the above named rivers, were found series of metamorphic rocks, which have been referred, from their position and lithological characters,

to the Silurian. Passing to the north of the Amazonas, they minutely investigated the geology of the vicinity of Monte Alegre and the Serra of Ereré. On the plain of Ereré were discovered sandstones and shales with characteristic Devonian fossils, corresponding more or less with those of the Hamilton and Corniferous groups of New York State. These were the first Devonian fossils found east of the Andes in South America.

One of the party examined the ancient Indian mounds of the island of Marajó, at the mouth of the Amazonas, at that time only imperfectly known, and discovered large quantities of richly ornamented pottery, mostly fragmentary. These have since been made the subject of considerable study by Professor Hartt. The sea coast was examined at several points, from Pará to Pernambuco, and, in the neighborhood of the latter city, the fossiliferous Cretaceous formations of the province of the same name, were studied for the first time. At all of the localities visited they made large collections in geology and zoology, which were sent to the United States and are now contained in the museum of Cornell University.

Prof. Hartt's researches on the Amazonas did not tend to bring proof of the former existence of glaciers there. The Serra of Ereré was found not to belong to the series of table-topped hills, as Prof. Agassiz had been led to suppose, but to consist of inclined strata of very irregular outline. The Devonian fossils of the plain were from a portion of the supposed "drift" material of Agassiz. Prof. Hartt did not find time to examine any of the true table-topped hills on this trip, and it was largely for the purpose of doing this that he returned to the Amazonas in 1870, accompanied only by Mr. O. A. Derby.

The table-topped Serra of Parauáquara and the Serra of Tauajurí, of another class, and both wholly unknown to science, were visited, but gave no evidence of having been formed through the agency of glaciers. The fossiliferous localities of Ereré and the Tapajos were reexamined, and larger collections made from them. The fresh-water shell heaps of Taperinha were carefully explored by Prof. Hartt, and the mounds of Marajó by Mr. Derby.

At no time on either of these two trips did Prof. Hartt lose a moment in idleness; when no other work could be done, he busied himself in studying the Mundurucú and Maué dialects of the modern Tupí language of the Amazonas, and in bringing together the stories and myths which are current in the tribes. He has prepared a large volume on the grammar, vocabulary, and stories of this language, which yet remains unpublished.

Prof. Hartt returned to Ithaca, N. Y., about January, 1872, where he remained two years and a half, giving all the time he could spare from his college duties to working up the results of his two Amazonian trips, with the aid of two assistants, Mr. O. A. Derby and myself. His reports were published, as soon as finished, in the journals of several scientific societies. During this time he also gave popular lectures on Brazil, in New York, Boston and Syracuse.

But Prof. Hartt was unable to continue long in this state of comparative quietude. In bringing together the results of his several trips to South America, with the object of explaining the geology of all Brazil, he saw how meagre were his data for this purpose, notwithstanding all that he and others had recently done, towards elucidating the structure of many portions of this vast region. He wished to extend his researches, and conceived the idea of organizing a survey of the whole Brazilian Empire, which has an area scarcely less than that of the United States. There was only one way of accomplishing such an undertaking; it must be supported by the government. Hartt ventured to bring the matter to the attention of some of his Brazilian friends, and his ideas met with such favor that, in 1874, he received an unofficial invitation from the Brazilian Minister of Agriculture, to submit a proposition for the systematic geological exploration of the Empire. In August of the same year he accordingly went to Rio de Janeiro, for the purpose of formally presenting his plans. Upon arriving at that city he was received with almost as much enthusiasm as was Prof. Agassiz nearly ten years earlier. He was honored for the good he had already done Brazil

through his private explorations; he was elected to the several Societies of Science and Literature in Rio de Janeiro, and invited to lecture. His thorough acquaintance with the language of the country enabled him to communicate freely with the people, and he soon found himself encircled with friends, who gladly gave their influence in advancing his laudable plans.

In his proposition for the Survey of Brazil, he advised the organization of a large party, to consist of three separate divisions, each complete in itself, and equipped for field research. Had his ideas been fully carried out he would have soon explored an immense tract of country, but the money requisite for so extensive an undertaking could not at that time be appropriated, and Hartt was forced to begin on a much smaller scale than he had wished. On the 1st of May, 1875, "A Comissão Geologica do Imperio do Brazil" was organized, with Prof. Hartt as chief, and the following assistants: Elias F. de P. Jordão, Engineer; O. A. Derby and Richard Rathbun, Assistant Geologists; and F. José de Freitas, praticante. Sñr. Marc Ferrez, photographer of the Imperial Navy, was appointed to the same position on the Geological Survey, where he was retained for a year and a half. Mr. John Branner was soon added to the corps. Sñr. Jordão retired from his position in the spring of 1876, and was succeeded by Mr. Luther Wagoner, who resigned in July, 1877. Mr. Frank Carpenter then became the topographer of the Survey, and continued in this capacity to the time of the death of Prof. Hartt. Mr. Derby and myself arrived in Brazil only at the close of 1875. No other changes than the above occurred in the personnel of the Commission, and the difficulties constantly attending the exploration of such a large country, with so small a corps, can be readily imagined.*

* It is most fitting to mention here the name of Major O. C. James, of Rio de Janeiro, the oldest and most valued friend of Prof. Hartt in Brazil. From the first day Prof. Hartt arrived in that country to the time of his death, he was constantly indebted to Major James for assistance and advice, and to him, in large part, was due the successful organization of the Geological Commission, for which he acted in the capacity of Secretary, his services being rendered gratuitously. His long experience in Brazil made him an invaluable auxiliary to the Commission, and he labored for it indefatigably.

When the National Museum of Rio de Janeiro was remodeled, in 1876, the Minister of Agriculture, having the matter in charge, solicited Prof. Hartt's assistance, and, at the same time, made him director of the department of Geology; but his many other duties soon forced him to relinquish the new task.

Prof. Hartt's plan of operations was to first make a preliminary reconnaissance of all the accessible portions of the Empire, before entering much into detail work; but, as will be seen in the sequel, he succeeded in very thoroughly investigating some of the regions he explored. The following general account of the explorations of the Brazilian Survey is based in part upon some of Prof. Hartt's unpublished reports. Regarding the character of the work, Prof. Hartt states in one of his late reports to the Minister: "As is the duty of every scientific man, I have carried on my investigations in a purely scientific way, hoping that later on they would not fail to be of practical importance." While awaiting instructions, Hartt visited the gold regions of São Gonçalo and Campanha. An account of the results of this trip was published in the *American Journal of Science and Arts* for June, 1876.

The active work of the Commission began in June, 1875. They explored the Cretaceous deposits near the coast, from Pernambuco to Parahyba do Norte, taking Maria Farinha, where Cretaceous fossils were found in 1870, as a basis. This formation was found to be very extensive and richly fossiliferous. With the marine fossils of Maria Farinha were discovered the remains of a large species of crocodile; at Iguarissú were found beds with fish teeth, mostly sharks, and also some reptilian teeth. To the west of the Cretaceous, and not far from the coast, is the gneiss zone. The coast southward to Cape St. Agostinho, Rio Formoso, the island of Sto. Aleixo, and the Rio São Francisco, to, and including, the beautiful falls of Paulo Affonso, were all examined, and on the latter river fossils were discovered in the Cretaceous formation. Extensive studies were made on the

sandstone reef of Pernambuco, and the coral reefs of Candeias, Maria Farinha and Parahyba do Norte, from which were obtained large collections of corals and other marine animals, and Sñr. Ferrez was very successful in taking photographs of all the interesting places and objects. At the close of the above series of explorations, a large part of the specimens and photographs, illustrating the results of the work, were prepared for the National Exposition at Rio in December, 1875, at which Prof. Hartt had the honor of lecturing in the presence of the Emperor. A series of these photographs were also exhibited in the Brazilian Department of the Philadelphia Centennial Exposition.

In the beginning of 1876, while one party was exploring the province of Sergipe, another was examining the geology and reefs of the bay of Bahia and vicinity. From the Cretaceous formation along the line of the Bahia Railroad were obtained a great abundance of fossil remains, among which were the genera *Lepidotus* and *Pisodus* of fishes, and *Crocodilus* and *Dinosaurius*, of reptiles. The diamond gravels of Camassari and Pojuca, near Bahia, were found to consist in large part of a rock resembling itacolumite, which, though not observed *in situ*, probably exists somewhere in the neighborhood. The large and, until that time, unexplored island in the bay of Bahia, called Itaparica, was examined and proved to be composed entirely of fossiliferous Cretaceous rocks, similar to those on the east side of the bay. On the Rio Itapicurú, in northern Bahia, the Post-Tertiary deposits yielded bones and teeth of the *Megatherium*, *Mastodon*, a very large species of *Capavara* (*Hydrochærus*), etc. In Sergipe, the geology of all the region between the sea coast and the Serra of Itabyana was investigated. This proved to be an interesting section of country, as its structure is quite varied. The Serra of Itabyana, which can be seen from the coast, consists of beds of sandstone, conglomerate, and limestone, dipping strongly toward the east, and probably of Palæozoic age, though yielding no fossils. Between the serra and the sea is the most

interesting Cretaceous basin of the coast of Brazil, valuable, not only for its scientific riches, but also for the fertility of its soil, which arises from the decomposition of limestones. The collection of fossils obtained from this Cretaceous area was probably larger than that from Pernambuco, and comprises Teleostean and Selachian fishes; several forms of Crustacea; Nautilus, Ammonites, Ceratites, Natica, Turritellites, Turritella, Janira, Ostrea, Trigonina, Cardium, Astarte, Mytilus, Gervillia, Pectunculus, Posidonomya, etc., among the Mollusca; Corals, Echini, a single large specimen of star-fish, etc., etc.

Mr. Branner spent two months in studying the geology and other natural history features of the island of Fernando de Noronha, which differs entirely in structure from the main-land, being of volcanic origin, and furnishing splendid illustrations of dykes and basaltic columns. Mr. Branner's work was fully illustrated by a fine series of photographs and sketches. At this time I was exploring, with the photographer, the southern coast of Bahia and the Abrolhos region. A large set of photographs of the Botocudo Indians was made by Sñr. Ferrez on this expedition, and forms a valuable contribution toward the study of that tribe.

During the latter half of 1876 and the first half of 1877, explorations were carried on in the southern coast provinces, as follows: in Santa Catharina by Prof. Hartt and Mr. Wagoner; in Paraná by Mr. Wagoner; and in São Paulo by myself. In Santa Catharina the regions investigated were the Carboniferous basin of the Tubarão, never before visited by a geologist, the "*sambaquis*" of Laguna, and the geology around the São Francisco do Sul. Many perfect skulls, ornaments, axes and other stone implements, and pottery were obtained from the "*sambaquis*." Mr. Wagoner made a geographical examination of the highlands west of the bay of Sta. Catharina, and from the Rio Itajahy to Coritibanos. The identity in structure of the Serra Geral and the Serra do Tubarão was proved. The fossils found in the Serra seem to be Carboniferous.

In São Paulo, I studied the metamorphic rocks from the Serra do Mar to the Serra do Mantiqueiro and beyond; the deposits of trap furnishing the "*terra roxa*," the rich land of the coffee region; the beginning of the Carboniferous basin in the south of São Paulo, containing remains of Saurians; and the "*sambaquis*" of the vicinity of the city of Santos. Mr. Wagoner's trip in Paraná was from Antonina, near the coast, to a point far into the interior of the province, passing Guarapuava where coal had been found. In the interior he discovered Palæozoic rocks with many fossils whose exact age has not yet been determined. The genera of Brachiopods represented are *Discina*, *Spirifera*, *Strophodonta*, *Streptorhynchus*, *Leptocœlia* (?), etc.; a small Ophiuran was very abundant. To complete the scientific work done to the south of Rio de Janeiro in connection with the Geological Commission, we must add the scientific results of a trip made by Mr. J. E. Mills to the gold regions of Rio Grande do Sul, of which a report was kindly furnished Prof. Hartt. Mr. Mills also contributed a very valuable report on the gold regions of Minas Geraes.

From July, 1876, to February, 1877, while the above described explorations were in progress to the south of Bahia, Mr. Derby was arriving at most important results in the valley of the Amazonas, which region he was well fitted to investigate, by reason of his former experiences there. He was accompanied by Dr. F. J. de Freitas and Mr. H. H. Smith, the latter of whom had already spent two years on the Amazonas, in studying its entomology and the geology of several sections. The most valuable, connected series of explorations by the Commission were those executed by this small party. They examined the Ereré-Monte-Alegre district, the Rio Mæcurú, wholly unknown to science, and the Rios Curuá and Trombetas, making maps of the entire region. Mr. Smith alone worked up minutely the district lying between Alenquer and the Mæcurú, and reëxamined the Carboniferous of the lower Tapajos. There was demonstrated to exist to the north of the Amazonas a large

series of Palæozoic fossiliferous rocks, including the Upper Silurian, Devonian and Carboniferous. The most important discovery was, that the Carboniferous of the lower Tapajos, and that of Maué-assú, extend to the north of the Amazonas, from the Trombetas far to the east of Monte Alegre. This fact is proved to a certainty by the stratigraphy of the beds and by their fossils. The same species of fossils that occur at Itaitúba were found on the Trombetas and Curuá, in the district of Cujubim, and in Tajury. The existence of a Carboniferous basin on the Amazonas, occupying an immense area, is thus settled beyond doubt; but the important question, "does it contain coal?" has not yet been answered. The region is generally so covered with a dense vegetation, and so level, that it is next to impossible to find any exposures of rock, except about the falls of the principal tributaries. On the Mæcurú and Curuá, to the north of Ereré, was found a rich Devonian fauna, differing only slightly from that already known from the latter locality. The Upper Silurian fossiliferous beds consist of compact flaggy sandstones, with shaly partings containing *Arthropycus Harlani*. In the sandstones are found *Lingula cuneata*, *Orthis hybrida*, *Bucania trilobata*, etc. Mr. Derby also examined the metamorphic regions both to the north and south of the Amazonas, the shell heaps of Taperinha and the mounds of Marajó, and will probably soon publish his results in full.

The details already given tell but half the story of the field work of the Geological Commission of Brazil. Immense geological, zoölogical, and ethnological collections had been sent in from all directions, amounting to nearly six hundred cases, which were deposited in a storehouse in Rio as fast as they were received. It became necessary to examine and study these collections, so as to supplement and complete the studies made in the field, and a single large room was awarded the Commission for this purpose. The task of opening and arranging this flood of rich material fell mostly upon me, and I soon found that the one room, large as it was, would not prop-

erly contain one-tenth of the collections. A large house was requested and finally secured, and conveniently served as a museum, and as a biological, chemical, and photographic laboratory.

In June, 1877, prompted by motives of economy, and unacquainted with the amount and value of the work being done by the Commission, Government gave orders for the temporary suspension of the Survey on the first of July. But after the Minister of Agriculture and other members of the Government had been convinced of the loss Brazil would sustain by suddenly discontinuing such an important undertaking, instructions were issued to have the work go on in Rio, at least until the close of the year. The Emperor, soon after returning to Rio (in the autumn of 1877), fresh from the Museums of the Old World and North America, carefully inspected the building and work of the Geological Commission. He was astonished to find that the small party which he had left eighteen months before, laboring quietly among the rocks of the north of the Empire, had built up in his own capital just such a laboratory of science as he had enjoyed tarrying in, in the many scientific centers he had lately visited. He showed a just appreciation of the value of the new Museum of Geology, both to his own country and to the world at large, and was generous in his words of praise to the talented chief, who had so dearly earned them. On leaving the building, almost the only thing he said was, "your work *shall* continue."

During the early part of last January, an entire change was made in the Ministry of Brazil, and before the several departments had been entirely reorganized and the appropriations determined upon, Professor Hartt died. There was no one to succeed him, and his large collections were placed in the care of the National Museum at Rio de Janeiro. It is expected that steps will be taken by the Brazilian Government at an early date toward publishing the many reports which were finished under the direction of Prof. Hartt. The extent of these and of the work done by the members of the Commission in

Rio, from July, 1877, to January, 1878, can be best understood from the final report of Prof. Hartt, made to the Minister of Agriculture last December, an English translation of which is appended to this paper.

The following brief account of the state of systematic geology in Brazil, at the time of Prof. Hartt's death, will assist us in understanding what he had accomplished in that important branch of research, since the publication of his book in 1870. The scanty material on this subject in my possession, necessarily renders this summary very incomplete.

Laurentian.—Composing the greater part of the plateau and mountain range of Guayana, the plateau of central Brazil, with the Serra do Mar and Serra do Mantiqueiro, and the Chiquitos plateau of Bolivia. This series is mainly composed of gneiss, gneiss-granite and syenite. Every effort was made to find traces of *Eozoön*, or of other fossils, in the limestones of this age, in the provinces of Rio de Janeiro and São Paulo, but without success.

Huronian and Lower Silurian.—The metamorphic deposits, lying on the southern edge of the plateau of Guayana and on the northern edge of that of Brazil, and consisting mostly of quartzites, metamorphic schists and crystalline limestones, the former still showing stratification, and wind and wave structure, have been referred to the Huronian and Lower Silurian. To the north of the Amazonas they have been examined on the Trombetas; to the south of the Amazonas, on the Tapajos and, doubtfully, on the Tocantins. (Observations by Mr. Derby and others.) The gold-bearing rocks of Minas Geraes are probably of this age, as well as the metamorphic series of some of the other provinces.

Upper Silurian.—Includes the sandstones and shales underlying the Devonian, to the north of the Amazonas, and containing *Arthropycus Harlani*, *Lingula cuneata*, etc. (Derby.)

Devonian.—The heavy series of sandstones, sandy shales, etc., with an abundance of fossils, at localities on the Mæcurú and Curuá, (Derby), and at Ereré, are equivalent

to about the Corniferous and Hamilton groups of New York State. There are higher beds of shales with *Spirophyton*. Shales with *Spirophyton* near Itaitúba, Tapajos, and without fossils on the Xingú possibly belong to the Devonian. (Derby.) To the north of the Amazonas the Devonian formation has been doubtfully traced as far west as the Rio Negro. (Rodriguez and Derby.) The Palæozoic fossils from the interior of Paraná are either Devonian or Carboniferous.

Carboniferous.—The large area underlaid by this formation on the Amazonas, was in part marked out in the preceding pages. Carboniferous rocks have been found on the Rio Negro and doubtfully in the province of Maranhão. In southern Brazil the extent of the deposits of this age is very great, ranging through São Paulo, Paraná, Santa Catharina and Rio Grande, and containing numerous seams of coal. Fossils are abundant in some places.

[The partially metamorphosed deposits, forming the Serra of Itabyana and other neighboring serras, are probably Palæozoic; they overlie the gneiss unconformably. Other more or less metamorphosed deposits have been referred to the Palæozoic.]

Triassic (?).—Extensive series of sandstones overlaid by trap, on the Serra of Sta. Catharina, and inland toward the Rio Paraná. Also doubtfully found in Sergipe.

Cretaceous.—Rio Purus, Upper Amazonas; sandstones overlying the Devonian of Ereré, with dicotyledonous leaves, probably Cretaceous; Braganza, province of Pará, (discovered by Sñr. Penna); Ceará; skirting the coast from near the city of Pernambuco to Parahyba do Norte; Province of Sergipe, near the sea-coast; Rio São Francisco, at several localities; Bahia de Todos os Santos; Abrolhos Islands, etc. It is possible that the Jurassic period is represented at some of the above localities.

Tertiary, with fossils on the Rio Marañon, and possibly at other localities; also the unfossiliferous deposits before enumerated.

Post Tertiary.—Lagoa Santa; interior of Bahia; Espirito Santo, etc.

Drift.—The glacial drift is probably limited to southern Brazil.

In addition to the voluminous reports prepared by Prof. Hartt, as chief of the Brazilian Survey, he also had the following works, which were written before he went to Brazil in 1874, nearly or quite ready for publication.

I. *Brazilian Antiquities*—about 500 pages, 4to, with about 50 heliotype plates and many engravings.

II. *Mythology of Brazilian Indians*—about 300 pages, 4to.

III. *Grammar, Dictionary, and Chrestomathy of the Tupi Language, Ancient and Modern*, 400 pages.

IV. *An Album* of about 100 photographic views, illustrating the country, people, etc., of the Lower Amazonas. To be accompanied by about 100 pages of text.

The preceding review of the scientific work of Prof. Hartt, though very incomplete, indicates how untiring must have been his industry. In order to judge of the real character and value of his investigations, we must refer to his publications. These, however, give us but a glimpse of the vast store of knowledge he had accumulated. The volumes he has left in manuscript will, when published, add greatly to his scientific standing, by making known to the world the variety and excellence of the work he had accomplished. Until then, only the few scientific associates who knew him intimately can award to him his just merits.

Hartt possessed in a high degree the qualities requisite to form a successful leader. He could plan effectively, directing his scattered forces with little effort and to the best advantage. He displayed the greatest skill in utilizing the diverse results from many sources, never, however, losing sight of the grand whole he was seeking to build up. He belonged to the modern school of Evolution, the theories of which had been sufficiently proved to him by many of his studies, and from these he obtained his great inspiration. Judging from his brilliant beginning, we are confident in asserting that, had he lived, he would have won for himself a place by the side of such investigators as De le Beche, Murchison, Logan and

others, like whom he was a pioneer in the special field of research he had entered. In the following report we have in his own words an account of his Brazilian work from July 1, 1877, to January 1, 1878.

"During the past six months the members of the Geological Commission have been quite exclusively employed in laboratory work in the building of the Commission in the Côte, the aim being to obtain before the end of the year the largest possible results from the discussion of the material collected to illustrate the geology of the region explored, and at the same time to put this material in the best possible order.

"It is but seven months since the Commission entered the house it now occupies, and has had space and facilities for opening and arranging its collections of rocks, fossils, minerals, etc. In April last it occupied a single room in the building of the Carta Geral, and only an insignificant part of the collection was accessible for study. Since then some four hundred boxes of specimens have been unpacked, the latter having been more or less carefully prepared and arranged in such a way as to be readily found when wanted. The manual labor alone involved in preparing and arranging all this material for study was in itself a gigantic task. So large is the number of specimens that I have not attempted to determine it exactly. But I estimate it roughly as much above five hundred thousand, so that the collections of the Commission form a large museum, and one of the highest value to science, because its material is unique; and I am sure that its money value to-day, if offered for sale, would more than equal the whole sum expended on the Commission.

"On leaving the field to take up the more difficult and nice work of the laboratory, it is the duty of the geological explorer to prepare his report on the district he has examined, his material being his note books and his collections of rocks, fossils, etc. The study and identification of collections, especially of fossils, is tedious and difficult, and can only be carried on rapidly and success-

fully where one has access to first-class libraries and geological collections, and where one may enjoy intercourse with scientific specialists. Indeed, unless one has made a specialty of the study of the groups of fossils he has collected in the field, even the most experienced geologist of Old World and American surveys is accustomed to hand over for description to specialists at home or abroad the collections he has made, and this recently was the case with the English 'Challenger' expedition, whose material has been distributed for study among the scientific men of the globe, and several years must elapse before the reports will have been handed in. The work of reducing scientific observations is slow and tedious, if conscientiously done, and it cannot be hastened without detriment to its accuracy; and scientific work, if not accurate, is worthless.

"The Geological Commission of Brazil found itself, on returning from the field, with an immense mass of most valuable material, for the most part new, and without a scientific library, without access to museums, and separated by an ocean from specialists in its various departments. The idea of working up palæontological and geological results under these conditions, and of presenting reports on a par of excellence with those of other geological commissions would seem utopian to foreign scientific men, and I should never have undertaken the work had not my knowledge of the country enabled me to foresee results and to prepare myself and my assistants beforehand for the probable work before us. Except for several years of preparatory work in the United States, the consulting of the best libraries and museums and the taking of advice of scientific men eminent in specialties likely to be of use in Brazil, and but for the fact that each man came to his work furnished with abundant notes and books, it would have been impossible to have done more than prepare mere broad descriptions of the parts of the country explored, and anything like the critical study of fossils, and the accurate determination of formations would have been absolutely impossible.

All this preliminary work, so exceedingly important to the Geological Commission, has cost nothing to government. Instead of being forced to send collections to foreign scientific men for study, the Geological Commission has been able, in its own laboratories and with its own resources, to prepare for publication a very considerable part of its results, though this work has naturally progressed much more slowly than it would have done under superior advantages. My great desire has been to lay a firm foundation for Brazilian geology in the development of palæontological localities and the accurate determination of characteristic formations by means of fossils, and to this end the Commission has labored with a degree of success surprising even to myself, and we find ourselves to-day with an *embarras de richesses*. The Commission as at present constituted comprises only six persons, on whom has fallen all this work of collecting, arranging, and studying this material, which in richness is to be compared with that of the 'Thayer,' or 'Hassler,' or 'Challenger' expeditions; and it is not reasonable to expect that, without the free access to scientific libraries, and to collections for comparison, the work of the Brazilian Commission should go on more rapidly than that of the foreign commissions where the material is divided up among dozens of specialists, and where the scientific man enjoys every advantage. As it is, it will be several years before the full results of these commissions are prepared for publication. For six persons to unpack, assort, prepare, and describe the immense collections made by the Geological Commission in less than one year, was an absolute impossibility, as every scientific man will agree with me, and in the six months generously granted me after the suppression of the Commission by the Camaras, I had only the hope of saving as large a fragment as possible of our results. It is needless to say that it has been entirely out of our power to finish the work, notwithstanding that the members of the Commission have worked unceasingly day and night on their herculean task. Neither is the discussion of the material

finished, nor are the collections fully determined or arranged. Everything possible has been done, but the work is not ended. I should state that I have been compelled by circumstances to adopt a system which I otherwise would not have followed. If, to begin with, I had had ample laboratories in the Côte and facilities for study, I should have from time to time recalled assistants, as their field work in certain localities was concluded, to work up their results in the laboratory, and this work would have gone on with the work of the field; but not having sufficient room in the Côte for the Commission, I was compelled to store away in a warehouse the hundreds of boxes of specimens sent by my assistants, and when the present house was taken, I found it necessary to recall my whole force in order to commence the systematic study of our results. We had scarcely begun this work when field work was put a stop to at the end of July, and since then we have been confined to the reduction of our reports.

“Since the end of July the whole of the collections have been examined, great numbers of specimens have been prepared and mounted by Messrs. Derby, Rathbun, Freitas and Branner, and some have been restored or reproduced in plaster by my preparador; the condition of the collection and its classification has been steadily improved, and it has been constantly under the most careful inspection to prevent injury by rats and cockroaches, which, without constant vigilance, destroy specimens and preparations, and injure or destroy labels. In no other geological museum that I have examined are collections better cared for or in better shape for work than ours. So immense, however, is the collection, and so abundant is it in new species, that only a small part is accurately determined and arranged, the rest bearing only general labels. In case of a suspension of the Commission and the dispersion of its members before an opportunity can be found to study and accurately determine these collections by the assistants who gathered them together, a very large part of this unworked-up

material will lose a large part or the whole of its value ; for, like the brief notes of a field note-book, their whole significance can only be understood by the one who made them.

“ Besides the work of preparing and arranging the collections, the work of the Commission, during the latter half of the year 1877-78, has been as follows:— Besides the general direction of the work of my assistants, I have devoted myself to the preparation of a long report on the Geology and Physical Geography of the Lower Amazonas, embracing all my work previous to the establishment of the Commission, together with the studies in the service of the Commission of Messrs. Derby, Freitas, Smith and Penna. This report, illustrated by numerous maps and drawings, is to be followed by extended papers by Messrs. Derby and Rathbun, describing the whole of the fossils of the Silurian, Devonian, and Carboniferous of the Amazonas. This report, prepared in English, and forming in itself a large volume, is nearly translated, and will be ready to be submitted in a little more than a month, and it will be found to be the most important contribution ever made to South American geology. I have pressed the preparation of this work, not only on account of its immediate scientific importance, but because our facilities for its preparation were greater than for that of any other. I have carried forward to greater or less completion several works on the reefs and harbors of the coast north of Rio, and an extended memoir on the archæological collections of the Commission, and the “ *sambaquis* ” of the coast. Recently I have been at work on the Geology and Physical Geography of the Provinces of Pernambuco, Alagoas, Sergipe, and Bahia, including the lower São Francisco, discussing the question of the *secca* in those provinces. This voluminous report will require yet some time for its completion. Mr. Derby has occupied himself almost exclusively with his Amazonian work, geological and palæontological, and his explorations in Bahia and Sergipe. About two months ago, as he was suffering from fever

contracted on the Amazonas, I sent him to São Paulo where he made, especially in the Sorocaba district, a valuable series of observations confirmatory of, and additional to, those of Mr. Rathbun. This last assistant has prepared an extended report of his excursion to São Paulo, giving the first intelligible detailed account of the geology of that province. He has finished his work on the geology of Bahia, on the coral reefs of that bay, and has concluded the corals and radiates collected by the Commission, which he has illustrated by a splendid series of photographs by his own hand, which is not equalled by any similar work that I have ever seen. I have already alluded to his studies of the Amazonian fossils. Mr. Branner has been busily engaged in the preparation and mounting of the Cretaceous fossils collected by Dr. Freitas and himself, in the provinces of Sergipe and Pernambuco, and in the preparation of a series of reports on the island of Fernando de Noronha, on the reefs of the north coast, and on a journey made by him to the interior of the province of Pernambuco, etc.

“Mr. Carpenter has been engaged in the reduction of the geographical observations of the various members of the Commission, in the preparation of a new map of the Lower Amazonas, in the revision of a paper on meteorology presented by Mr. Wagoner, and recently in the preparation of a carefully considered exposé of the methods employed by the United States Government in geographical surveying in the western territories and states,—methods sufficiently accurate, and especially adapted, for a new and unexplored country, and most admirably adapted for a geological survey, where geographical and topographical work must to a certain extent be subordinated to the needs of geological exploration. Mr. Carpenter, after a severe training as a civil engineer, was employed by Lieut. Wheeler on his survey, under the War Department, of the Western territories, and has had several years of practical experience in the field. I have thought that, even if the Geological Commission of Brazil should be definitely stopped, his

paper would make one of the most valuable contributions that the Commission could make to Brazilian geographical and geological science. A few years ago Mr. Carpenter published in the United States a very short article on the same subject, which for its novelty and its clearness attracted general attention. The memoir written for the Commission is a very much more extensive and valuable document, presenting for the first time clearly the methods chosen after long experience by the United States Government, for the exploration of a region almost identical with Brazil in its leading features, and which has been sanctioned by the most eminent of explorers.

“Dr. Freitas, though suffering from the effects of his journey on the Amazonas, has continued faithfully to perform his arduous duty of translating into Portuguese the palæontological reports of Messrs. Derby and Rathbun. I cannot speak in too high praise of his fidelity and industry. As it was simply impossible for one person to translate the material rapidly accumulating from the different members of the Commission, I found it necessary to call in the aid of my friend, Dr. Americo dos Santos, who, during the last two months, has done everything in his power to aid in the work, translating carefully the memoir of Mr. Carpenter and various papers embraced in the voluminous relatorios on the Lower Amazonas.

“In accordance with the custom of other commissions and museums, I have employed an experienced Italian artist as a preparador of specimens, and for the making of casts and reproductions of rare fossils and antiquities to be sent abroad, and about one thousand reproductions in plaster-paris are nearly ready for distribution, and I feel sure that this work will be most highly appreciated abroad, especially at this time when American antiquities are sought for with so great an avidity.”

The following list of the scientific publications of Prof. Hartt has been made as complete as the material to which I have had access permitted.

1. The Gold of Nova Scotia of Pre-Carboniferous Age. *Canadian Naturalist*, I, No. 6, 459-461, 1864.

2. Observations on the Geology of Southern New Brunswick, made principally during the Summer of 1864, by Prof. L. W. Bailey and Messrs. George F. Matthew and C. F. Hartt; prepared and arranged, with a Geological Map, by L. W. Bailey, A.M. Contains the three following special reports by C. F. Hartt:—

(a) Preliminary Notice of a Fauna of the Primordial Period in the Vicinity of St. John, N. B., pp. 30-31. (Published also in *Can. Nat.*, VII, 318-320 1865; and in Dawson's "Acadian Geology," 2d Ed., 1868, 641-643.)

(b) On the Devonian Plant Locality of the "Fern Ledges," Lancaster, New Brunswick, with a detailed Section, and Notes on the Fossils, 131-141. (Includes report of S. H. Scudder on the Devonian insects. An abstract was published in "Acadian Geology," 1868, 513-523.)

(c) List of New Brunswick Fossils, 143-147.

3. The Recent Bird-Tracks of the Basin of Minas. *American Naturalist*, I, 169-176, 234-243, 1867.

4. On a Sub-division of the Acadian Carboniferous Limestones, with a Description of a Section across these Rocks at Windsor, N. S. *Can. Nat.*, III, 212-224, 1867. (A summary of the results recorded in this paper are given in "Acadian Geology," 1868, 279-280.)

5. [Descriptions and Notices of the Trilobites and other Fossils of the Acadian Group, at St. John, N. B.] "Acadian Geology," 1868, 643-657, with many figures. (Prepared by Dr. Dawson from the MS. notes of Prof. Hartt.)

6. Résumé of a Lecture on the "Growth of the South American Continent," delivered before the Library Association, Ithaca, N. Y., Dec. 4, 1868. *Cornell Era*, Dec. 12, 1868. (Pamphlet reprint contains 8 pages.)

7. A Vacation Trip to Brazil. *Amer. Nat.*, I, 642-651, 1868.

8. A Naturalist in Brazil. *Amer. Nat.*, II, 1-13, with illustrations, 1868.

9. The Cruise of the "Abrothos." *Amer. Nat.*, II, 85-93, with illustrations, 1868.

10. On the Botocudos of Brazil, (abstract). *Proceed. Amer. Ass. Adv. Sci.*, 18th meeting, Salem, 1869, 273-274.

11. Thayer Expedition.—Scientific Results of a Journey in Brazil, by Louis Agassiz and his Travelling Companions.—Geology and Physical Geography of Brazil, by Ch. Fred. Hartt, with illustrations and maps, 8°, pp. 620. Boston: Fields, Osgood & Co., 1870.

12. Discovery of Lower Carboniferous Fossils on the Rio Tapajos. (A letter written near Monte Alegre, Rio Amazonas, Oct. 5, 1870.) *Amer. Nat.*, IV, 694-695, 1871.

13. Devonian Rocks in the Amazonian Valley. *Amer. Nat.*, V, 121-122, 1871.

14. Amazonian Drift. *Amer. Jour. Sci. and Arts*, I, April, 1871, 294-296.

15. Brazilian Rock Inscriptions. *Amer. Nat.*, v, 139-147, with 9 plates, 1871.
16. The Ancient Indian Pottery of Marajó, Brazil. *Amer. Nat.*, v, 259-271, with numerous figures, 1871.
17. Recent Explorations in the Valley of the Amazonas, with Map. *Jour. Amer. Geog. Soc.*, N. Y., III, 1872, 231-252, (read May 16, 1871).
18. [The Origin of the Basin of the Amazonas (abstract).] *Proc. Boston Soc. Nat. Hist.*, xv, 153-154, 1872.
19. On the Tertiary Basin of the Marañon. *Amer. Jour. Sci. and Arts*, iv, July, 1872, 53-58.
20. On the Occurrence of Face-Urns in Brazil. *Amer. Nat.*, vi, 607-610, with one large figure, 1872.
21. Notes on the Lingoa Geral or Modern Tupí of the Amazonas. *Trans. Amer. Philog. Ass.*, 1872, pp. 20.
22. O Mytho do Curupira. *Aurora Brasileira*, Ithaca, N. Y., Oct. and Nov. 1873. (Also separate reprint, pp. 12.)
23. Morgan Expeditions, 1870-71.—Contributions to the Geology and Physical Geography of the Lower Amazonas. The Ereré-Monte-Alegre District and the Table-Topped Hills. *Bull. Buffalo Soc. Nat. Sci.*, 1, No. 4, 201-235, with maps and sketches, 1874.
24. Preliminary Report of the Morgan Expeditions, 1870-71.—Report of a Reconnaissance of the Lower Tapajos. *Bull. Cornell University (Science)*, No. 1, pp. 37, with map, 1874.
25. Evolution in Ornament. *Popular Science Monthly*, January, 1875, 266-275, with many figures.
26. Morgan Expeditions, 1870-71.—On the Devonian Trilobites and Mollusks of Ereré, Province of Pará, Brazil; by Ch. Fred. Hartt and Richard Rathbun. *Ann. Lyc. Nat. Hist.*, N. Y., xi, 110-127, May, 1875.
27. The Indian Cemetery of the Gruta das Mumias, Southern Minas Geraes, Brazil. *Amer. Nat.*, ix, 205-217 (illustrated), 1875.
28. Amazonian Tortoise Myths. Rio de Janeiro, Wm. Scully, publisher. 1875, pp. 40.
29. Notes on the Manufacture of Pottery among Savage Races. Published at the office of the "South American Mail," Rio de Janeiro, 1875, pp. 70.
30. Explorações Científicas,—I. Comissão Geologica do Brazil. Catalogo da Exposição de Obras Publicas do Ministerio da Agricultura, Rio de Janeiro, 1876, 95-106.
31. Nota sobre Algumas Tangas de Barro Cosido dos Antigos Indigenas da Ilha de Marajó. *Archivos do Museu Nacional do Rio de Janeiro*, 1, Trimestre 1º, 21-25, Estampas III, IV & V, 1876.
32. Discripção dos Objectos de Pedra de Origem Indigena conservados no Museu Nacional. *Arch. do Mus. Nac. do Rio de Janeiro*, 1, Trim. 2º & 3º, 45-53, Estampas VII & VIII, & 2 figuras, 1876.
33. The Geological Survey of Brazil. First Preliminary Report made to the Counselor Thomaz José Coelho de Almeida, Minister and Secretary of State for Agriculture, etc.; by Ch. Fred. Hartt, Chief of the Geological Commission of the Empire of Brazil, Rio de Janeiro, 1876. Translated and abridged by Prof. T. B. Comstock. *Amer. Jour. Sci. and Arts*, xi, June, 1877, 466-473.

LIST OF SCIENTIFIC PAPERS BY DIFFERENT AUTHORS ON SUBJECTS PERTAINING
TO THE BRAZILIAN EXPLORATIONS OF PROF. HARTT.

1. Notice of Corals and Echinoderms collected by Prof. C. F. Hartt, at the Abrolhos Reefs, Province of Bahia, Brazil, 1867; by Prof. A. E. Verrill. *Trans. Conn. Acad. of Arts and Sciences*, I, 351-371, pl. IV, 1868.
2. Notice of some New Reptilian Remains from the Cretaceous of Brazil; by Prof. O. C. Marsh. *Amer. Jour. Sci. and Arts*, XLVII, May, 1869, 390-392.
3. Abstract of a Notice of the Crustacea collected by Prof. C. F. Hartt, on the Coast of Brazil, in 1867; by S. I. Smith. *Amer. Jour. Sci. and Arts*, XLVIII, 1869, 388-391.
4. Notice of the Crustacea collected by Prof. C. F. Hartt on the Coast of Brazil in 1867.—List of the described species of Brazilian Podophthalmia; by S. I. Smith. *Trans. Conn. Acad. of Arts and Sciences*, II, pt. I, 1-42, pl. I, 1870.
5. Morgan Expeditions, 1870-71.—On the Devonian Brachiopoda of Ereré, Province of Pará, Brazil; by Richard Rathbun. *Bull. Buffalo Soc. Nat. Sci.*, I, No. 4, 236-261, plates 8-10, 1874.
6. On the Carboniferous Brachiopoda of Itaitúba, Rio Tapajos, Province of Pará, Brazil; by O. A. Derby, M. S. *Bull. Cornell University (Science)*, I, No. 2, 1-63, plates I-IX, 1874.
7. Preliminary Report on the Cretaceous Lamellibranchs collected in the vicinity of Pernambuco, Brazil, on the Morgan Expedition of 1870; by Richard Rathbun. *Proc. Boston Soc. Nat. Hist.*, XVII, 241-256, 1874.
8. The Geological Commission of Brazil.—Additions to the Echinoid fauna of Brazil; by Richard Rathbun. *Amer. Jour. Sci. and Arts*, xv, Feb. 1878, 82-84.
9. The Devonian Brachiopoda of the Province of Pará, Brazil; by Richard Rathbun. *Proc. Boston Soc. Nat. Hist.*, xx, pp. 14-39, 1878.
10. A Contribution to the Geology of the Lower Amazonas; by Orville A. Derby. *Proc. Amer. Phil. Soc.*, 1879, pp. 155-178. (Portuguese version, in *Archivos do Museu Nacional de Rio de Janeiro*, II, pp. 77-104, 1878.
11. On the Geology of the Diamantiferous Region of the Province of Paraná, Brazil; by Orville A. Derby. *Proc. Amer. Phil. Soc.*, 1879, pp. 251-258.
12. The Artificial Mounds of the Island of Marajó, Brazil; by Orville A. Derby. *Amer. Nat.*, XIII, No. 4, pp. 224-229, 1879.
13. Prof. Ch. Fred. Hartt on the Brazilian Sandstone Reefs; by Richard Rathbun. *Amer. Nat.*, XIII, No. 6, pp. 347-358, 1879.
14. Brazilian Corals and Coral Reefs; by Richard Rathbun. *Amer. Nat.*, XIII, No. 9, pp. 539-551, 1879.
15. A List of the Brazilian Echinoderms, with Notes on their Distribution, etc.; by Richard Rathbun. *Trans. Conn. Acad. of Arts and Sciences*, v, pp. 139-158, 1879.
16. Geology of the Region surrounding the Bahia de Todos os Santos; by Orville A. Derby. (In course of publication.)
17. On the Geology and other Natural Features of the Island of Itaparica, Province of Bahia, Brazil; by Richard Rathbun. (In course of publication.)

THE FOLLOWING TRIBUTES TO THE MEMORY OF PROFESSOR HARTT, EXPRESS,
IN A MEASURE, THE DEEP FEELING OF SORROW OCCASIONED BY THE NEWS OF
HIS UNTIMELY DEATH :

Principal J. W. Dawson, of McGill College, Montreal, Canada, in his annual address as President, before the Natural History Society of Montreal, May 18, 1878, spoke as follows :

" The second name, which it becomes me to mention here, is that of a man less known to many of you, but intimately known to me, and whom we have the right to claim as a Canadian geologist, and one of the highest standing—Charles Frederick Hartt, late Professor of Geology in Cornell University, and Director of the Geological Survey of Brazil, who died at Rio de Janeiro on the 18th of March last, at the early age of thirty-eight years. He was a native of Nova Scotia ; and at Horton, in that Province, where he studied at Acadia College, and while still a student, he became known to me as a diligent and successful collector of fossils of the Lower Carboniferous rocks. He subsequently engaged in educational work in St. John, and with his friend, Mr. Matthew, had the honor of first rendering intelligible the complicated geology of that district, and of discovering and almost exhausting its rich Devonian Flora and Fauna. The collection and determination of the Cambrian fossils, of what is now known as the Acadian group, and the excavation of the numerous fossil plants of the Devonian of the same district, constitute, in my judgment, two of the most important advances ever made in the Palæontology of Eastern America, and are even yet bearing fruit. It was my good fortune to be able to aid and encourage Mr. Hartt in these earlier efforts, to determine his Lower Carboniferous and Devonian plants, and to afford him, in my 'Acadian Geology,' a medium of publication for his Primordial fossils. Acting under my advice, Mr. Hartt, in order to perfect his knowledge of palæontology, entered the school at that time recently established by Agassiz, at Cambridge. This led to his appointment to a chair of geology first at Vassar College, and subsequently at Cornell, and also to his connection with Brazil, which began with his being attached in 1865 to the 'Thayer Expedition' to that country, under Prof. Agassiz. The magnificent opening for geological work in Brazil seems to have fascinated his mind, and I remember well the enthusiasm with which he wrote to me, at a subsequent time, of the almost identical fauna and flora of the Brazilian Coal-measures with those he had in earlier days explored in Nova Scotia. In 1870 he returned to that country with an expedition from Cornell, and in 1875 he was appointed to the direction of the Survey, then instituted by the Brazilian government, having already had a semi-official connection with the government for about a year. In the three years in which he worked in connection with the Brazilian government, he had explored and mapped large districts of the country, had accumulated a valuable geological museum,

and had prepared the MS. of voluminous reports which he was about to publish at the time of his death. It is to be hoped that some worthy successor may still give them to the world.

"In his character Hartt was, like our friend Carpenter, an amiable, exemplary, benevolent and Christian man, and I have known few of our younger men of science who gave greater promise of brilliant success.

"His rapid advancement to high and important positions, shows that science is not without its advantages as a profession, and may, perhaps, serve to encourage others to devote themselves to similar pursuits, however such ardor may be checked by the remembrance of his early death. But it is better to live well and to good purpose, than merely to live long."

Prof. A. S. Packard, Jr., in "The American Naturalist" for May, 1878:

"It is with great sorrow that we announce the sudden death of Prof. Charles Frederic Hartt, Chief of the Brazilian Geological Commission. He died at Rio de Janeiro, March 18. His untimely death is a great calamity, as, after nearly three years of constant exploration, over a large part of Brazil, he had begun to prepare for publication the results of the researches of himself and assistants, Messrs. Derby and Rathbun. He was born at Fredericton, New Brunswick, in 1840, and graduated at Acadia College, at Wolfville, Nova Scotia. He was a student under Agassiz from 1862 until 1865, and during that time investigated the Devonian plant and insect beds of St. John, and made important researches in the Cambrian fossils of the Acadian series at St. John. He then accompanied Agassiz as Geologist of his journey to Brazil, and subsequently made three visits to the coast regions and the Amazonas, the results of his explorations being comprised in his work on 'The Geology and Physical Geography of Brazil,' published in 1870. Several years previous he was appointed Professor of Geology and Physical Geography at Cornell University. He made a specialty of Brazilian Geology, and mastered the Portuguese language, investigated the natural history and archæology of that country, and so identified himself with its physical history, that it seemed as a matter of course that the Emperor of Brazil should honor himself by appointing the young explorer Chief of the Imperial Geological Commission. This was in May, 1875; since then his studies have extended widely over the Empire, including the unraveling of the geology of the Amazon, consisting of Silurian, Devonian and Carboniferous rocks, the thorough examination of the coast and interior of the Province of Pernambuco, a reconnoissance of the diamond and gold districts of Minas Geraes, the examination of large areas in São Paulo and Santa Catharina. The survey had collected enormous quantities of fossils and zoölogical material from the Devonian and Carboniferous formations in the Amazonian valley, large numbers of remains of vertebrates and invertebrates from Pernambuco, including many new reptilian forms, mainly Cretaceous. For the last six months but little field work had been done, and publication was progressing rapidly. Prof. Hartt also made a

thorough study of the coral reefs of the coast of Pernambuco. He also amassed many facts regarding the language, manners and customs of the Tupis, Guaranis and other Indian tribes, and Brazilian archæology.

"Professor Hartt, besides being a geologist, palæontologist and zoölogist, was a capital linguist and philologist. He had powers of rapid acquisition and great versatility. He was a person of warm sympathies, and of a cheerful, light-hearted spirit that endeared him to all with whom he came in contact. To the readers of this journal, to which he often contributed on geological and archæological subjects, his powers of exposition are well known. His death is a serious blow to American Science. All will deplore his loss; his memory will be cherished by his fellow-students and associates who knew him best and appreciated his moral worth and his intellectual and scientific attainments."

Prof. James D. Dana, in "The American Journal of Science and Arts," April, 1878:

"Professor Hartt, according to a telegram from Rio Janeiro, died of yellow fever soon after the middle of March. Prof. Hartt was born in 1840, at Fredericton, N. B. In his youth he evinced a taste for geology, and discovered at St. John many fossil plants, and the oldest specimens of fossilized insects then known. He studied from 1862 to 1865, under Agassiz, at Cambridge, and accompanied that eminent scientist to Brazil as geologist of his expedition. On his return he was appointed Professor of Geology and Physical Geography at Cornell University. After his first visit to Brazil, Professor Hartt acquired a thorough knowledge of the Portuguese language, and that Empire became his favorite field of study. He returned three times and zealously explored the northern provinces, giving most attention to the valley of the Amazon. During one of these expeditions, undertaken under the auspices of the Hon. Edwin D. Morgan, of New York, he sent home an interesting series of letters for publication. Papers containing some of the geological results of these expeditions are noticed in this Journal; in volumes i, iv, vii, viii and x, of the third series (1871-'75). In May, of 1875, the Brazilian Government placed Professor Hartt in charge of the Geological Survey of the Empire, and gave him a liberal salary; since then he has been carrying forward this great work. The results thus far obtained have been only partially published. A translation of his first Report of Progress, made by Professor T. B. Comstock, is contained in this Journal, in vol. xi, 1876, and a brief announcement of further discoveries in vol. xii. In 1870, he published his principal work, 'The Geology and Physical Geography of Brazil.' He felt at home in Rio, where he enjoyed excellent health, and was greatly esteemed. His family reside at Buffalo, N. Y. His death is a great loss to the scientific world."





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